Review

Programmed Aging, Digital Genetics, and the Evolution of Acquisition Traits in Mammals

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Programmed Aging, Digital Genetics, and the Evolution of Acquisition Traits in Mammals

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Abstract: *Programmed aging* refers to the idea that mammals (and some other multiparous sexually reproducing organisms) evolved complex biological mechanisms that cause gradually increasing fitness deterioration and internally limit individual organism lifetimes. The rationale is that this process enhances the survival (non-extinction) of a species population. *Evolvability* theories propose that mammals have evolved design characteristics that aid their ability to evolve, that is, reduce the time required for a particular increment of evolutionary adaptation and/or increase the precision with which the adaptation can be performed. Because an increase in evolvability aids a population in escaping extinction, evolution selects the associated design characteristics. Both of these concepts conflict with traditional (Darwinian) theory regarding the nature of evolution. However, more recent genetics discoveries have exposed rich detail regarding the nature of the evolution process including the fact that biological inheritance involves the transmission of organism design information from parent to descendant in *digital form*. These discoveries have acted to support both programmed aging and evolvability theories. *Acquisition traits* are those that depend for their evolutionary (fitness) value on the acquisition of something that gradually accumulates during an organism's life but is not transmitted genetically to descendants. This situation causes these traits including language, immunity, intelligence, and social status to represent a special need for evolvability and programmed aging.

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Introduction

Traditional (Darwinian) theory regarding the mechanics of evolution[1] suggests that the evolution process causes organisms to acquire design characteristics that aid an *individual* possessing them to produce more adult descendants.

More recent evolutionary mechanics theories such as group selection[2], kin selection[3],and evolvability theory[4,5] suggest that evolution causes organisms to acquire design characteristics that cause a *population* of species members to better avoid extinction. Multiple modern programmed aging theories (e.g. [6,7,8,9]) are based on these ideas. A much earlier (1882) programmed death theory[10] was widely rejected because it conflicted with traditional evolutionary mechanics theory and preceded the appearance of the supporting theories mentioned above.

In the vast majority of cases the individual vs population issue makes no difference because a trait that benefits an individual generally also benefits a population of those individuals. In addition, an organism design characteristic that *causes* the death of a parent can fit with traditional theory if doing so increases the chance that descendants of that parent will become adults. This was often a plausible possibility in (semelparous) organisms that only reproduce once.

Details of Darwin's thinking strongly support the individual-based concept. These include the idea that evolution is driven by the occurrence of mutations *that occur in a single individual* and then are inherited by and alter the designs of subsequent descendant individuals. Traditional concepts provided an explanation for the vast majority of organism design characteristics and are still widely accepted. Traditional theory also appears to substantially explain the evolution process as applied to prokaryote species such as bacteria.

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A minor exception[11] (1872) concerned the evolutionary nature of aging (senescence) in mammals and other diploid, sexually reproducing multiparous organisms. Since these organisms can nominally reproduce indefinitely, aging clearly limits an individual's ability to reproduce and therefore could not be an evolved characteristic according to traditional theory despite otherwise closely resembling an evolved design feature. Another exception concerned some apparently inherited animal behaviors in which an animal risks its life to protect an unrelated animal[2]. There is still no widely agreed solution for these issues+.

However, amazing, and quite recent advances in genetics technology, and subsequent genetics discoveries[12] have exposed rich detail regarding the mechanisms associated with biological inheritance. One major discovery is that biological inheritance involves transmission of information concerning an organism's design in *digital form* between parent and descendant of any organism. All digital information transfer methods possess common characteristics, benefits, and limitations[5] briefly summarized below.

Another major discovery concerned the fact that the biological inheritance process in sexually reproducing species was vastly different from the process that applied to the simpler single-cell organisms[12] that appeared earlier. These differences conveyed substantial advantages to the evolution process[4]. In other words, the ability to evolve has itself evolved substantially between single-cell haploid species and their descendant diploid sexually reproducing species. The earlier traditional theory assumed that the ability to evolve was a constant inherent "natural" property of life.

Another discovery was that while *new* mutations are key to the evolution of single-cell haploid species, they are much less involved in the evolution of any particular mammal (or other diploid, sexually reproducing multiparous species). This is because substantial evolution can occur *within* a mammal species without new mutations by means of *recombining* mutational differences that already exist in the genome of a mammal. This has major implications regarding the traditional mutation-based evolution concept and supports multiple theories that propose that evolution in mammals is based on the success of populations as opposed to individuals as described above.

Finally, the complex evolved mechanisms associated with sexual reproduction and the recombination process produce inheritable variation, even between siblings[5]. As described by Darwin, inheritable variation between individuals is required by the evolution process.

Digital Genetics

While there were hints of binary behavior such as seen by Mendel in 1865[13], definitive description of the digital nature of the biological inheritance scheme was made in 1953[14] and 1958[15]. These works determined that digital information describing organism designs is conveyed by the *sequence* in which different nucleotides are found in DNA molecules. Since there are four possible nucleotides, each nucleotide represents two bits of information. There are many benefits and limitations that are common to any digital information transfer scheme including human speech communications. These therefore apply to biological inheritance[12] as well as the sort of systems involved in information transfer for digital television or the Internet. Here is a brief summary of some digital benefits and limitations:

Perfect copies of information: Although errors can occasionally occur, information transfer generally can be completed with no errors. Copies of copies of copies can be accomplished indefinitely. This is an absolutely essential feature of biological inheritance. The evolution of Earth life has progressed incrementally and accumulatively to current species from ancestors that lived billions of years ago. The information that controls organism design has therefore incrementally accumulated during that period. Extensive copying of information stored in cells of individual multi-cell organisms is also required *during* their lives. The reader can well imagine how many copies of copies were required. *Analog* information transfer systems such as LP records, and analog tape recording are inherently subject to noise that makes multiple successive copies of copies infeasible. Note that inheritable variation between individuals *is not* an inherent property of a digital system but is the result of complex evolved mechanisms.

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Sexual reproduction involves a special copying process in which information from two individuals is merged to produce a new, single, genome. See evolvability implications below.

Symmetry and scale: If architects provide a detailed (digital) design for the left half of a building, they could add a footnote: "Except for details A, B, and C make the right half to be a mirror image copy of the left half." They could also insert a footnote: "For version B of this building multiply all dimensions by 1.25." This illustrates that it requires little information transfer to handle symmetry and scale by copying information. Examples are everywhere in animals.

Synchronization: Information elements such as words, sentences, paragraphs, etc. require *synchronization* between the transmitting element and the receiving element or copy. In human verbal or written communications, synchronization is provided by silent periods or un-inked spaces. Regarding the Internet and other digital communications methods, synchronization is provided by digital patterns that do not convey information but provide synchronization. In the genetic scheme, synchronization involves patterns such as start codons.

Repeat sequences: Extensive sequential duplication of a very simple digital sequence such as 1100110011001100110011001100… contains no information and no synchronization cues. Lengths of repeat sequences can vary during sexual reproduction because of the lack of synchronization.

Quantizing: Digital information is quantized, that is, represents discrete values as opposed to a continuum of values. More precision requires a longer digital sequence to convey. For example, 3.1 requires fewer digits but is less precise than 3.14159. It is the quantization feature that enables the perfect copies.

Errors: Errors occasionally occur. Digital communications schemes generally involve a method for detecting errors. In the inheritance scheme an error with substantial phenotypic effect can be considered a mutation likely to result in a substantial loss of fitness and is therefore selected out by natural selection. As Darwin suggested, mutations that are retained are likely to only have a small phenotypic effect because any large change would tend to be adverse.

Data inversion: The invert of a digital information sequence carries the same information as the original. For example, 10110110100111 carries the same information as 01001001011000. This effect is seen operating during copying of DNA information.

Evolvability

Traditional theory proposes that the ability to evolve is a fixed property of all living organisms. All organisms are affected by mutations and natural selection. The idea that an organism's ability to evolve is *variable* and affected by specific organism design features is therefore invalid. However, genetics discoveries demonstrated that massive changes to the mechanics of inheritance and evolution occurred between the evolution of prokaryotes and the subsequent evolution of descendant sexually reproducing eukaryotes. Evolvability is therefore a variable that can be affected by elements of an organism's design. An organism design characteristic that increases evolvability can be selected by the evolution process because increasing the rate and/or precision of evolutionary adaptation would reduce the probability that a population would become extinct. These concepts are described in detail elsewhere [9,4].

Many features of the genomic design of sexually reproducing species clearly increase evolvability:

Speciation: Sexual reproduction requires a very high degree of commonality between the mating individuals not only regarding the design information being conveyed but also the details of the *format* or non-information aspects of the digital scheme including synchronization. Genes and their promoters contain the information. Details of the mammal format include linked chromosome pairs, number of chromosomes, position of a particular gene within a chromosome, position of a particular gene on a different chromosome, repeat sequences, telomeres, etc. Genetics discoveries show that closely related mammal species have very similar genes and therefore similar designs but drastically different formats[12]. If a population of a particular mammal species was geographically isolated from another population of the same species, eventually format differences would prevent cross breeding between the two species populations (or between either population and any other species). Format

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differences tend to differ rapidly between individuals. For example, differences in the lengths of repeat sequences are used to identify individual humans for law enforcement purposes. The rapid format change feature of sexual reproduction has major evolvability implications because speciation allows each reproductively isolated population to independently evolve a design that best fits its particular ecological situation.

Evolution of Acquisition Traits

An acquisition trait depends for its evolutionary value on the acquisition of something that incrementally increases during an organism's life but is not genetically transmitted to descendants as described in the examples below. Acquisition traits represent a special evolvability need for an internally limited lifespan.

Intelligence has two components. First is the ability to acquire and incrementally and accumulatively store *information* about an animal's external world, i.e. *experience (*memories and knowledge*)*. The second is the ability to process and apply the acquired information in a way that increases fitness by altering the animal's behavior. i.e., *intelligence*. Intelligence is useless without experience and experience is useless without intelligence. Experience nominally increases with age. *Wisdom* can loosely be considered to be the product of intelligence and experience. It is collective wisdom that increases the chance that a population will survive extinction. This is the origin of the Intelligence Quotient or IQ concept. The evolutionary difficulty is that if aging and the consequent gradual decline in fitness did not exist, older and less intelligent but more experienced individuals would have a fitness advantage over more intelligent but less experienced individuals thus interfering with the evolution of intelligence. Programmed mammal aging, by gradually decreasing fitness as a function of age, compensates for the gradual increase in wisdom and consequent age-advantage that would otherwise occur. Aging therefore enhances the evolution of intelligence.

Digital Language is mainly a capability of humans and involves the transmission of information (in digital form) between individuals. Humans are not born possessing any particular language, but they *are* born possessing the ability to develop a language or learn and use an existing language, typically initially taught by parents. They also possess the necessary evolved brain, mouth, teeth, tongue, vocal cord, and hearing features for verbal digital speech communications. Very young children in groups of two or more have been seen to develop their own primitive language prior to learning their native language and virtually everyone invents new words that occasionally are widely adapted. Names of people, places, and things are continuously acquired. Language capability involves evolution of substantial brain tissue (e.g. Wernicke's area and Broca's area)[16] that is specialized to handle language communications.

Some diseases specifically affect language[16], and language capability varies substantially between individuals. Specialized language elements and terminology are associated with different sciences, industries, and activities. Language capability allows *specialization*. Not every member of a population needs to possess the terminology of a particular trade (e.g. Carpentry, Law, Medicine, or Nuclear Physics) in order to benefit from those specialties.

Language and intelligence are highly related. To the extent that you "think" using your acquired languages and terminology, your thought process is highly dependent on your specific language capability and the efficiency and extent of that language. Learning languages and terminology can require a substantial fraction of an individual's lifespan. Note that while words and meanings grossly vary between languages, other aspects are common such as the need for quiet periods to provide synchronization.

Because language is acquired and accumulates during life it is an acquisition trait and benefits from programmed aging and internally limited lifespan. While humans and domesticated animals and plants are no longer evolving in a Darwinian sense, human languages continue to evolve and adapt, and collective intelligence therefore increases.

The Grandmother Hypothesis[17] refers to an evolutionary conundrum: Why do human females lose reproductive capability (menopause) much earlier in their lives than females of other mammal species. Loss of reproductive capability that is obviously programmed by the same sort of evolved

clock mechanism that controls timing of puberty and other reproductive functions would appear to represent a substantial reduction in fitness by limiting the female's reproductive potential. Although males participate in reproduction, limitations on a population's reproductive capability are substantially determined by females[9]. Various explanations for this observation have been suggested[17]. One possible explanation is that humans have extensive verbal communications capability, not possessed by other mammals. Because of this there could exist a particular age, beyond which a human female would produce a larger fitness benefit for a population by teaching existing children as opposed to caring for additional young of its own.

Immunity: Genetics discoveries and other biological discoveries have revealed that very complex evolved biological mechanisms[12] are associated with the acquisition of biological immunity. Like the other acquisition traits, the immunity mechanisms allow the progressive acquisition and accumulation of immunity against different infectious agents, that in some cases can last for the life of the organism.

Social Status: Many animals have a social organization and cooperate to operate as groups. This behavior has obvious survival benefits for the group and especially for its leaders. The King is much less likely to die in a conflict than the foot soldier. A group needs a leader and other levels of social status. At least in humans, status can be inherited. Status also conveys reproductive advantages. Since status is acquired and progressively accumulated, it is an acquisition trait and benefits from programmed aging and internally limited lifetime.

Conclusions

The existence of acquisition traits represents a special need for gradual aging and internally limited lifespan.

Organism genomic design and digital information processing are very complex subjects, and the brief treatment above is intended to demonstrate that the evolution process has itself evolved during the time that life has existed on Earth and show that ongoing genomics discoveries and the digital nature of biological inheritance have many implications for evolutionary mechanics theory and dependent aging theories.

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